

**УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ” - ШТИП**  
**ФАКУЛТЕТ ЗА ИНФОРМАТИКА**

---

ISSN:1857-8691

**ГОДИШЕН ЗБОРНИК**  
**2013**  
**YEARBOOK**  
**2013**

**ГОДИНА 2**

**VOLUME II**

---

**GOCE DELCEV UNIVERSITY - STIP**  
**FACULTY OF COMPUTER SCIENCE**

**УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ“ – ШТИП**  
**ФАКУЛТЕТ ЗА ИНФОРМАТИКА**

---



**ГОДИШЕН ЗБОРНИК**  
**2013**  
**YEARBOOK**  
**2013**

**ГОДИНА 2**

**МАРТ, 2014**

**VOLUME II**

---

**GOCE DELCEV UNIVERSITY – STIP**  
**FACULTY OF COMPUTER SCIENCE**

**ГОДИШЕН ЗБОРНИК  
ФАКУЛТЕТ ЗА ИНФОРМАТИКА  
YEARBOOK  
FACULTY OF COMPUTER SCIENCE**

За издавачот:

**Проф д-р Владо Гичев**

**Издавачки совет**

Проф. д-р Саша Митрев  
Проф. д-р Лилјана Колева - Гудева  
Проф. д-р Владо Гичев  
Проф. д-р Цвета Мартиновска  
Проф. д-р Татајана Атанасова - Пачемска  
Доц. д-р Зоран Здравев  
Доц. д-р Александра Милева  
Доц. д-р Сашо Коцески  
Доц. д-р Наташа Коцеска  
Доц. д-р Зоран Утковски  
Доц. д-р Игор Стојановиќ  
Доц. д-р Благој Делипетров

**Редакциски одбор**

Проф. д-р Цвета Мартиновска  
Проф. д-р Татајана Атанасова - Пачемска  
Доц. д-р Наташа Коцеска  
Доц. д-р Зоран Утковски  
Доц. д-р Игор Стојановиќ  
Доц. д-р Александра Милева  
Доц. д-р Зоран Здравев

**Главен и одговорен уредник**

Доц. д-р Зоран Здравев

**Јазично уредување**

Даница Гавриловска - Атанасовска  
(македонски јазик)  
Павлинка Павлова-Митева  
(англиски јазик)

**Техничко уредување**

Славе Димитров  
Благој Михов

**Редакција и администрација**  
Универзитет „Гоце Делчев“ - Штип  
Факултет за информатика  
ул. „Крсте Мисирков“ 10-А  
п. фах 201, 2000 Штип  
Р. Македонија

**Editorial board**

Prof. Saša Mitrev, Ph.D.  
Prof. Liljana Koleva - Gudeva, Ph.D.  
Prof. Vlado Gicev, Ph.D.  
Prof. Cveta Martinovska, Ph.D.  
Prof. Tatjana Atanasova - Pacemska, Ph.D.  
Ass. Prof. Zoran Zdravev, Ph.D.  
Ass. Prof. Aleksandra Mileva, Ph.D.  
Ass. Prof. Saso Koceski, Ph.D.  
Ass. Prof. Natasa Koceska, Ph.D.  
Ass. Prof. Zoran Utkovski, Ph.D.  
Ass. Prof. Igor Stojanovik, Ph.D.  
Ass. Prof. Blagoj Delipetrov, Ph.D.

**Editorial staff**

Prof. Cveta Martinovska, Ph.D.  
Prof. Tatjana Atanasova - Pacemska, Ph.D.  
Ass. Prof. Natasa Koceska, Ph.D.  
Ass. Prof. Zoran Utkovski, Ph.D.  
Ass. Prof. Igor Stojanovik, Ph.D.  
Ass. Prof. Aleksandra Mileva, Ph.D.  
Ass. Prof. Zoran Zdravev, Ph.D.

**Managing/ Editor in chief**

Ass. Prof. Zoran Zdravev, Ph.D.

**Language editor**

Danica Gavrilovska-Atanasovska  
(macedonian language)  
Pavlinka Pavlova-Miteva  
(english language)

**Technical editor**

Slave Dimitrov  
Blagoj Mihov

**Address of the editorial office**

Goce Delcev University – Stip  
Faculty of Computer Science  
Krstе Misirkov 10-A  
PO box 201, 2000 Štip,  
R. of Macedonia

**СОДРЖИНА  
CONTENT**

<b>CALCULATION OF MULTI-STATE TWO TERMINAL RELIABILITY</b> Natasha Stojkovic, Limonka Lazarova and Marija Miteva .....	5
<b>INCREASING THE FLEXIBILITY AND APPLICATION OF THE B- SPLINE CURVE</b> Julijana Citkuseva, Aleksandra Stojanova, Elena Gelova .....	11
<b>WAVELET APPLICATION IN SOLVING ORDINARY DIFFERENTIAL EQUATIONS USING GALERKIN METHOD</b> Jasmina Veta Buralieva, Sanja Kostadinova and Katerina Hadzi-Velkova Saneva .....	17
<b>ПРОИЗВОДИ НА ДИСТРИБУЦИИ ВО КОЛОМБООВА АЛГЕБРА</b> Марија Митева, Билјана Јолевска-Тунеска, Лимонка Лазарова .....	27
<b>ПРИМЕНА НА МЕТОДОТ CRANK-NICOLSON ЗА РЕШАВАЊЕ НА ТОПЛИНСКИ РАВЕНКИ</b> Мирјана Коцалева, Владо Гичев .....	35
<b>S-BOXES – PARAMETERS, CHARACTERISTICS AND CLASSIFICATIONS</b> Dusan Bikov, Stefka Bouyuklieva and Aleksandra Stojanova .....	47
<b>ПРЕБАРУВАЊЕ ИНФОРМАЦИИ ВО ЕРП СИСТЕМИ: АРТАИИС СТУДИЈА НА СЛУЧАЈ</b> Ѓорѓи Гичев, Ана Паневска, Ивана Атанасова, Зоран Здравев, Цвета Мартиновска-Банде, Јован Пехчевски .....	53
<b>ЕДУКАТИВНО ПОДАТОЧНО РУДАРЕЊЕ СО MOODLE 2.4</b> Зоран Милевски, Зоран Здравев .....	65
<b>ПРЕГЛЕД НА ТЕХНИКИ ЗА ПРЕПОЗНАВАЊЕ НА ЛИК ОД ВИДЕО</b> Ана Љуботенска, Игор Стојановиќ .....	77
<b>ИНТЕРНЕТ АПЛИКАЦИЈА ЗА ОБРАБОТКА НА СЛИКИ СО МАТРИЧНИ ТРАНСФОРМАЦИИ</b> Иван Стојанов, Ана Љуботенска, Игор Стојановиќ, Зоран Здравев .....	85
<b>УТАУТ И НЕЈЗИНАТА ПРИМЕНА ВО ОБРАЗОВНА СРЕДИНА: ПРЕГЛЕД НА СОСТОЈБАТА</b> Мирјана Коцалева, Игор Стојановиќ, Зоран Здравев .....	95



## CALCULATION OF MULTI-STATE TWO TERMINAL RELIABILITY

Natasha Stojkovic<sup>1</sup>, Limonka Lazarova<sup>2</sup> and Marija Miteva<sup>3</sup>

<sup>1</sup>Faculty of Computer Science, “Goce Delcev” University– Stip  
(natasa.maksimova, limonka.lazarova, marija.miteva)@ugd.edu.mk

**Abstract.** Traditionally, reliability of the transportation system has been analyzed from a binary perspective. It is assumed that a system and its components can be in either a working or a failed state. But, many transportation systems as: telecommunication systems, water distribution, gas and oil production and hydropower generation systems are consisting of elements that may operate in more than two states. The problem that we consider in this paper is known as the multi-state two terminal reliability computation. The multi – state two terminal reliability can be computed with the formula of inclusion and exclusion, if the minimal path vector or minimal cut vector are known.

**Keywords:** multi-state systems, network reliability, minimal path vectors, minimal cut vectors.

### 1 Introduction

Two-terminal network reliability for binary transportation system has been studied in various ways. For the binary network it is assumed that a whole system and its components can be in two states: working or failed state. However, the binary approach does not completely describe some transportation systems. Such systems are telecommunication systems, water distribution, gas and oil production and hydropower generation systems. These networks and its components may operate in any of several intermediate states and better results may be obtained using a multi-state reliability approach.[1] The authors developed a multi-state approach for exact computation of multi-state two-terminal reliability at demeaned level  $d$  ( $M2TR_d$ ). The multi-state two terminal reliability is defined as the probability that a demand of  $d$  units can be transmitted from source to sink nodes through multi-state edges [2]. The multi – state two terminal reliability can be computed if the minimal path vector or minimal cut vectors are known. In the literature many algorithms for calculating on minimal path or cut vectors are known.

Some algorithms for obtaining minimal path or cut vectors are given in [1], [2], [3] and [4]. In [1] is developed a multi-state approach for exact computation of multi-state two-terminal reliability. In the paper is proposed algorithm for obtaining minimal path vector. Disadvantage of this algorithm is that it gives candidates minimal path vectors that are not minimal. In [2] is proposed algorithm for obtaining minimal cut vectors for the multi-state two-terminal transportation system. The disadvantage of this algorithm is that it works only for weak homogeneous components. The components can have different number of state, but the first state of the components has to be the same. In [3]

is proposed algorithm for obtaining minimal path vectors. This algorithm has restriction for the values of capacities on the edges. The capacities on the edges can be only valued from the set of integer number. In [4], it is proposed an algorithm for obtaining the minimal path vector that does not require any restrictions for the values of the capacities of the links.

## 2 Basic definition

In this paragraph we will give some basic definitions for binary two terminal network.

Let  $G(V, E)$  be a multi- state two terminal network. By  $V$  the set of nodes is denoted, and by  $E = \{e_i \mid 1 \leq i \leq |E|\}$  the set of edges is denoted. Multi-state edge is defined as an edge of the system, which has a set of states  $\{r \leq 100\% \mid r \in [0, 1]\}$ . The state 0 is appropriate in case when there is no stream over the edge. The state 100% is appropriate on the state, when the edge works with full capacity. Intermediate states are all states in which could be found edge between the state 0 and the state in which the system works with total capacity. State space set is the vector which presents the state of the components.

For example, let the edge of the transport system has three different states: 0%, 50%, 100%. Then the vector  $(0, 0.5, 1)$  is the vector of the states of that edge.

For any multi-state edge, the vector of the capacity (**Capacity Vector - Capacity State Set**) is obtained as a product of the full capacity of the edge and the vector of the state of that link. Let suppose that the edge described before, in perfect conditions could transfer flow equal to 8 units. The vector of the capacities, obtained in this way is equal to  $S_i = (8 \cdot 0, 8 \cdot 0.5, 8 \cdot 1) = (0, 4, 8)$ .

**Capacity state set S**, as the set of the all possible capacities from the source to the sink, for the total system is defined. For some simplifications, the states could be numerated in different ways. For example, it can be supposed that the perfect state at the level 2,50% corresponds to 1, and the state of the total breakdown corresponds to 0. In this way, the vector  $(0, 1, 2)$  is obtained.

Let  $x_i$  be the state of the link  $e_i$ . The vector  $\vec{x} = (x_1, x_2, \dots, x_n)$  which describes the states of all components of the system, is called **state vector**. The set of all state vectors is called state of the system  $N = S_1 \times S_2 \times \dots \times S_{|E|}$ .

The function  $\varphi: N \rightarrow S$  where  $\varphi(\vec{x})$  is the potential capacity from the source to the sink. If the system is in the state  $\vec{x}$ , it is called **multi – state structural function**.

**Definition 1. Multi-state two terminal reliability for the level  $d$  ( $M2TR_d$ )** is the probability of the event, that the flow is larger or equal to  $d$  and could be successfully transferred from the source to the sink.

$$M2TR_d = P\left(\varphi(\vec{x}) \geq d\right) \quad (1)$$

**Definition 2.** A vector  $\vec{y}$  is said to be less than  $\vec{x}$ ,  $\vec{y} < \vec{x}$ , (or dominated by  $\vec{x}$ ) if  $\forall i, y_i \leq x_i$  and for some  $k, y_k < x_k$ .

**Definition 3.** A vector  $\vec{x}$  is said to be a **minimal path vector to level  $d$**  if  $\varphi(\vec{x}) \geq d$  and if for every  $\vec{y} < \vec{x}$ ,  $\varphi(\vec{y}) < d$ .

**Definition 4.** A vector  $\vec{x}$  is said to be a **minimal cut vector to level  $d$**  if  $\varphi(\vec{x}) < d$  and if for every other  $\vec{y} > \vec{x}$ ,  $\varphi(\vec{y}) \geq d$ . [4,5]

In order to determine the structure of the transport system we define binary path vector. We are considering multi-state transport system with set of the nodes  $V$  and set of the edges  $E = \{e_i | 1 \leq i \leq n\}$ . We consider transportation system with the same nodes and edges. All the edges in this system are binaries, i.e. the set of the state of the links is  $\{0,1\}$ . Let  $\vec{v}$  be the minimal path vector for this transportation system. We say that  $\vec{v}$  is binary minimal path vector for the multi-state transport system. With BPV we denote the set of binary minimal path vectors.

With  $TS = (V, E, BPV, S, VP)$ , we denote the transportation system, where  $V$  is the set of the nodes,  $E$  is the set of the edges,  $BPV$  is the set of binary minimal path vectors,  $S$  is the set of capacity vectors of the components and  $VP$  is the set of the probabilities on the level of the components, where  $\vec{p}_i$  is vector of the probabilities on the  $i$ -th edges i.e.  $p_{id} = P(x_i = d)$ .

### 3 Calculating on the multi – state two terminal reliability

We will show how the reliability of multi state system, when the minimal path vectors are known, can be calculated. For the binary system, reliability could be solved by the following formula:



$$R = P\left(\bigcup_{h=1}^j \mathcal{P}_h\right) = \sum_{h=1}^j P(\mathcal{P}_h) - \sum_{h < k}^j P(\mathcal{P}_h \cap \mathcal{P}_k) + \dots + (-1)^j P(\mathcal{P}_1 \cap \dots \cap \mathcal{P}_j).$$

(2)

where  $j$  is a number of minimal paths, and  $\mathcal{P}_h$  is a  $h$  - the minimal path [5].

This formula can be extended for the new structure of the vectors from the minimal sets. In the case of multi state system  $M2TR_d$  can be obtained with the following modification of the formula of inclusion and exclusion

$$M2TR_d = \sum_{h=1}^T P(\bar{x} \geq \bar{y}_h) - \sum_{h < k}^T P(\bar{x} \geq \bar{y}_h \wedge \bar{x} \geq \bar{y}_k) + \dots + (-1)^T P(\bar{x} \geq \bar{y}_1 \wedge \dots \wedge \bar{x} \geq \bar{y}_T)$$

(3)

where  $T$  is number of the  $MPV_d$  (minimal path vectors on level  $d$ ) and  $\bar{y}_h \in MPV_d$ . By using of the notation

$$\max(\bar{z}_1, \dots, \bar{z}_s) = (\max(z_1^{(1)}, \dots, z_s^{(1)}), \dots, \max(z_1^{(l)}, \dots, z_s^{(l)})) \quad (4)$$

where  $z_u^{(v)}$  is  $v$ -th coordinate of the coordinate  $\bar{z}_u$ , and the equation (3) can be written in the form:

$$M2TR_d = \sum_{h=1}^T P(\bar{x} \geq \bar{y}_h) - \sum_{h < k}^T P(\bar{x} \geq \max(\bar{y}_h, \bar{y}_k)) + \dots + (-1)^T P(\bar{x} \geq \max(\bar{y}_1, \dots, \bar{y}_T))$$

(5)

---

#### Algorithm for reliability calculating

---

**Input:** Binary minimal path vectors  $BPV$ , set of the capacity vectors of the components  $S$ , and the set of the probabilities of the components levels  $VP$ .

**Output:** Reliabilities  $M2TR_d$ , for  $m < d < M$ ,  $m$  is the minimal level of the system work and  $M$  is the maximal level of the system work.

**Step 1.** Finding the minimal path vectors for level  $d$ ,  $D = \{\vec{z}_1, \vec{z}_2, \dots, \vec{z}_n\}$  with the algorithm proposed in [1-4].

**Step 2.** Finding all possible non empty subsets of the set  $D$ .

**Step 3.** For every subset  $D_r$ ,  $1 \leq r \leq 2^T - 1$  obtained in the step 2, it is find the supremum,  $\vec{v}_r = \sup D_r$ , according to the ordering relation  $f$  given in definition 2, in this way every coordinate is equal to the maximum of the appropriate vector coordinates in that subset.

**Step 4.** Finding of the probabilities  $P(\varphi(\vec{x}) \geq \vec{v}_r)$  and application of the formula 5 in order to obtain the reliability  $M2TR_d$ .

From the previous algorithm we can concluded that multi – state two terminal transportation system can be computed if minimal path vectors are given. In the Example 1, we will show minimal path vectors for level 1,2,3,4 for the system from Figure 1, and appropriate reliability.

**Example 1.** Let us consider the simple transportation system in Figure 1.

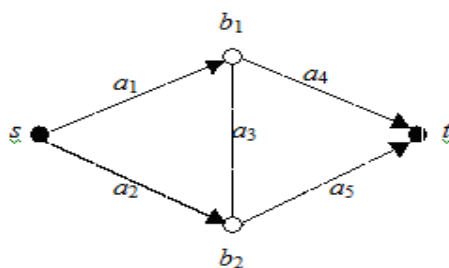


Figure 1. Two terminal transportation system

Capacities of the edges are  $S_1=\{0,1,2\}$ ,  $S_2=\{0,1,2\}$ ,  $S_3=\{0,1\}$ ,  $S_4=\{0,1\}$  and  $S_5=\{0,1,2,3\}$ . Probabilities that the edges can be in some state are:  $p_1=(0.1,0.1,0.8)$ ,  $p_2=(0.1,0.1,0.8)$ ,  $p_3=(0.1,0.9)$ ,  $p_4=(0.1,0.9)$  and  $p_5=(0.1,0.05,0.05,0.8)$ .

The vector of maximal state will be  $M=(2,2,1,1,3)$ .

We suppose that binary path vectors that are minimal path vectors to level 1 are known. With  $MP_i$  we will denote minimal path vector to level  $i$ .

$MP_1=\{(1,0,1,0,1), (1,0,0,1,0), (0,1,1,1,0), (0,1,0,0,1)\}$

$M2TR_1=0.97686$ .

$MP_2 = \{(2,0,1,1,1), (1,1,0,1,1), (1,1,1,0,2), (0,2,1,1,1), (0,2,0,0,2)\}$

$M2TR_2=0.84614$

$MP_3 = \{(2,1,1,1,2), (1,2,0,1,2), (1,2,1,0,3)\}$

$M2TR_3=0.64584$

$MP_4 = \{(2,2,1,1,3)\}$

$M2TR_4=0.3686$

## 4 Conclusion

This paper presents an algorithm for calculating a multi-state two terminal reliability. With this algorithm reliability to level  $d$  can be calculated when the minimal path vectors to level  $d$  are known.

## References

- [1] J.E. Ramirez-Marquez and D. Coit, D. (2003): *Alternative Approach for Analyzing Multistate Network Reliability*, IERC Conference Proceedings 2003
- [2] J.E. Ramirez-Marquez, D. Coit, and M. Tortorella: *Multi-state Two-terminal Reliability: A Generalized Cut-Set Approach*, Rutgers University IE Working Paper 2004
- [3] M. Mihova, M. and N. Synagina: *An algorithm for calculating multi-state network reliability using minimal path vectors*, The 6<sup>th</sup> international conference for Informatics and Information Technology (CIIT 2008)
- [4] M. Mihova M, N. Maksimova, Z. Popeska: *An algorithm for calculating multi-state network reliability with arbitrary capacities of the links*”- Fourth International Bulgarian-Greek Conference Computer Science’2008 (170-175)
- [5] Н. Максимова (2009): *Надежност на повеќе- состојбени двотерминални транспортни системи*. Магистерска теза, Институт за информатика, ПМФ Скопје

